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HYPERTHERMAL RESEARCH FACILITY

PROGRESS REPORT NO. 3

OTS PRICE

XEROX $ [redacted]

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HYPERTHERMAL RESEARCH FACILITY

The 1.8 megawatt arc-heated Hyperthermal Research Facility (HRF) is currently in operation at General Dynamics/Fort Worth. Basically this facility is a high enthalpy (18,000 Btu/lb) free jet, supersonic/hypersonic wind tunnel which uses gases such as air, nitrogen, argon, etc., as the primary working fluid. The gas is heated in a magnetically stabilized electric arc plasma generator, expanded through an axisymmetric nozzle into a free jet test section and exhausted through a diffuser, cooling section, and steam jet ejector system. Water-cooled copper electrodes are used in the plasma generator to reduce the contamination in the test stream. Figure 1 is a schematic of the facility.

The HRF presently is in the check-out and calibration phase. Initial operation was achieved in February, 1962. To date the plasma generator has been run at maximum design pressure (450 psia) and at power levels up to 1.3 megawatts.

Work during the past nine months has been concerned primarily with the elimination of various mechanical difficulties and the development of instrumentation for reliable measurement of both facility operating parameters and test stream properties. It is expected that basic calibration of the facility should be completed during 1963.

One of the major problems in operating an arc-heated facility is in obtaining the measurements needed to define the test stream condition. Results of a recent GD/FW corporate-funded study

(Ref. 1) indicated there is an optimum combination of parameters which should be measured to completely specify the state of a high enthalpy supersonic stream composed of a mixture of oxygen and nitrogen. These parameters are (1) free stream static pressure, (2) free stream static temperature, (3) stagnation pressure behind a normal shock, (4) dissociation fraction of oxygen, and (5) dissociation fraction of nitrogen. From these parameters, the free stream density, static and total enthalpy, and free stream velocity may be computed with minimum error. Accuracy can be improved by additional, independent measurement of any of the computed parameters.

Another corporate funded program currently being conducted is the theoretical study by Brock (Ref. 2) on the flow of a high enthalpy gas, in which the one-dimensional, non-equilibrium nozzle flow of dissociated and ionized air is being investigated.

The primary function of the HRF is ablation testing and the simulation of re-entry thermal environments. The estimated range of enthalpy which can be achieved with the HRF arc heater is shown in Figure 2 as a function of chamber pressure. Experimental data obtained to date are also shown. Figure 3 shows the predicted range of conditions that can be simulated, superimposed on typical envelopes of re-entry heat transfer rates. Nozzles that will be available for testing are listed in Table I along with a brief description and purpose. These nozzles were used in predicting the range of test simulation.

REFERENCES

1. Brock, O. R., Measurements Required in a Hypersonid Dissociated Air Stream to Define Stream Conditions, GD/FW ERR-FW-029.

2. Brock, O. R., The One-Dimensional, Non-equilibrium Nozzle Flow of Dissociated and Ionized Air, GD/FW, to be published.

HYPERTHERMAL RESEARCH FACILITY SCHEMATIC

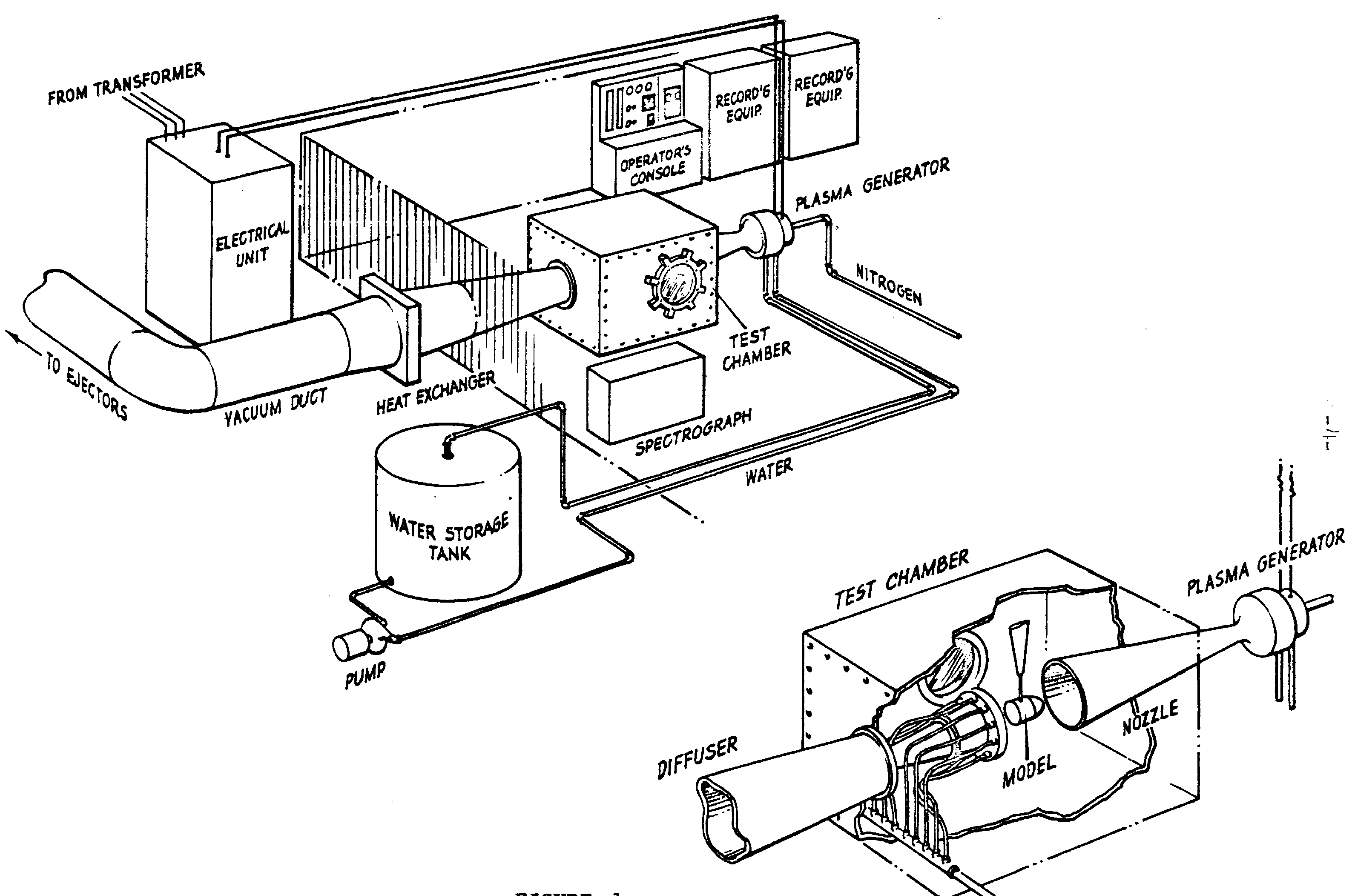

FIGURE 1

HRF PLASMA GENERATOR PERFORMANCE

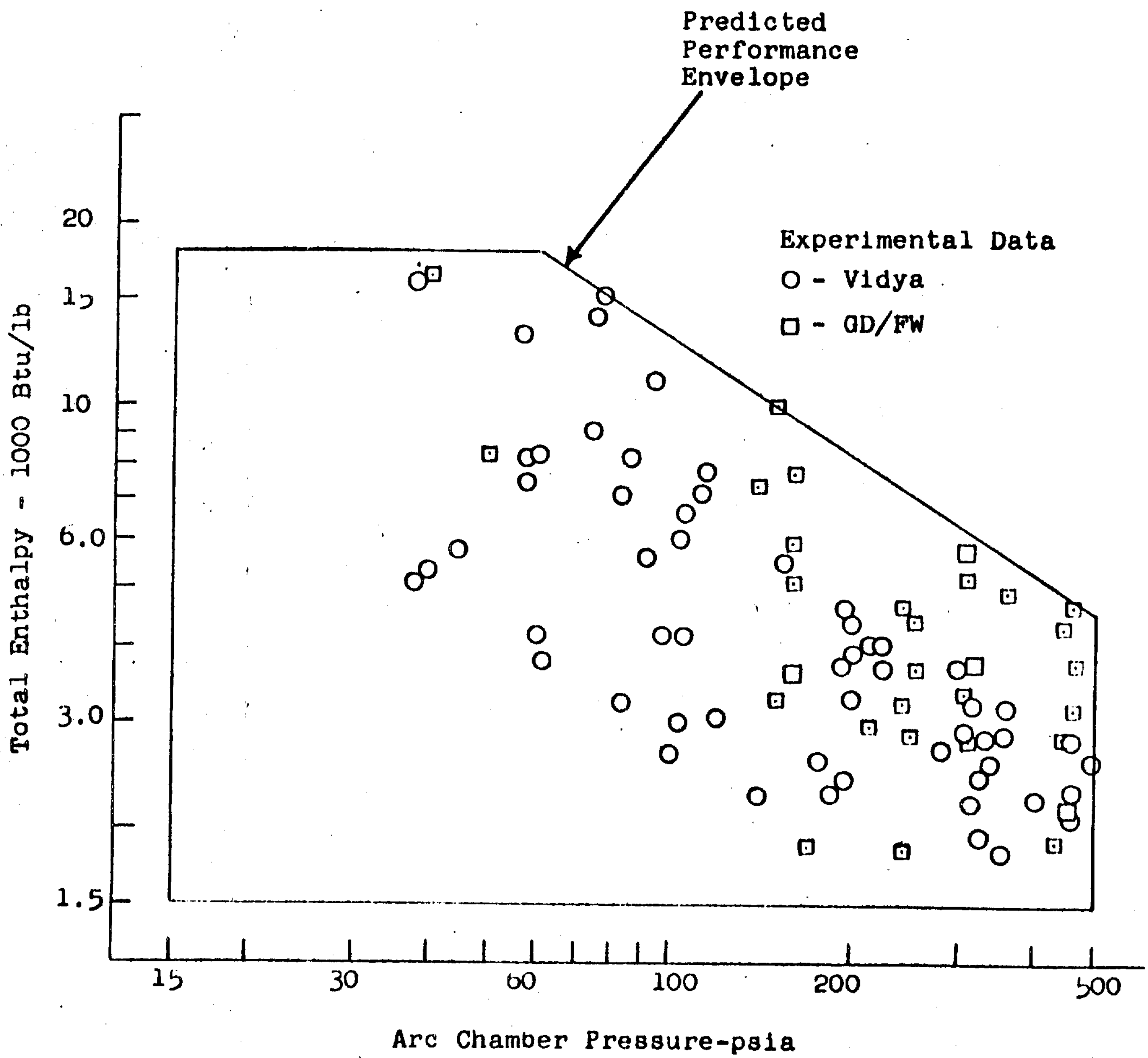

FIGURE 2

Summary of HRF Heat Transfer Simulation Capability

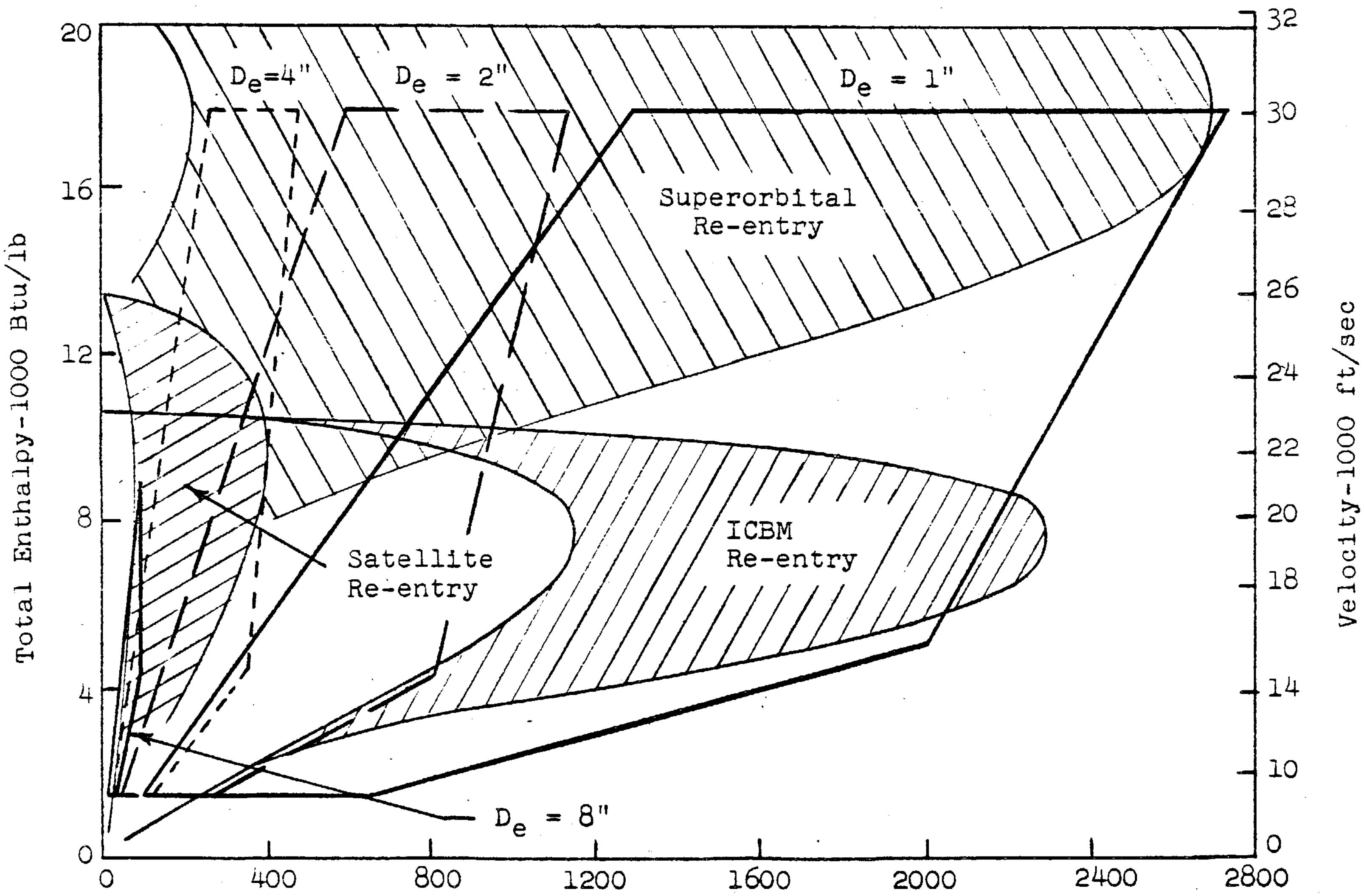

FIGURE 3

TABLE 1

HRF NOZZLES

No.	Throat Diam. Inches	Exit Diam. Inches	Type	Principle Purpose
1	2.0	2.0	Basic arc chamber exit	Subsonic H/T testing; low pressure–high enthalpy
2	0.20	0.20	Sonic nozzle	Calibration of plasma generator, sonic heat transfer testing of small models
3	0.20	4	15^{o} conical nozzle	Heat transfer testing with Mach ≈ 8 (also useful for aerodynamic testing)
4	0.20	8	extension attached to above nozzle	Heat transfer testing with Mach ≈ 12 (also useful for aerodynamic testing)
5	(0.253)	(1.0)	15^{o} conical nozzle	Heat transfer testing with Mach ≈ 3; to be designed for testing at maximum tunnel enthalpy
6	(0.253)	(2.0)	extension attached to above nozzle	Heat transfer testing with Mach ≈ 6; to be designed for testing at maximum tunnel enthalpy